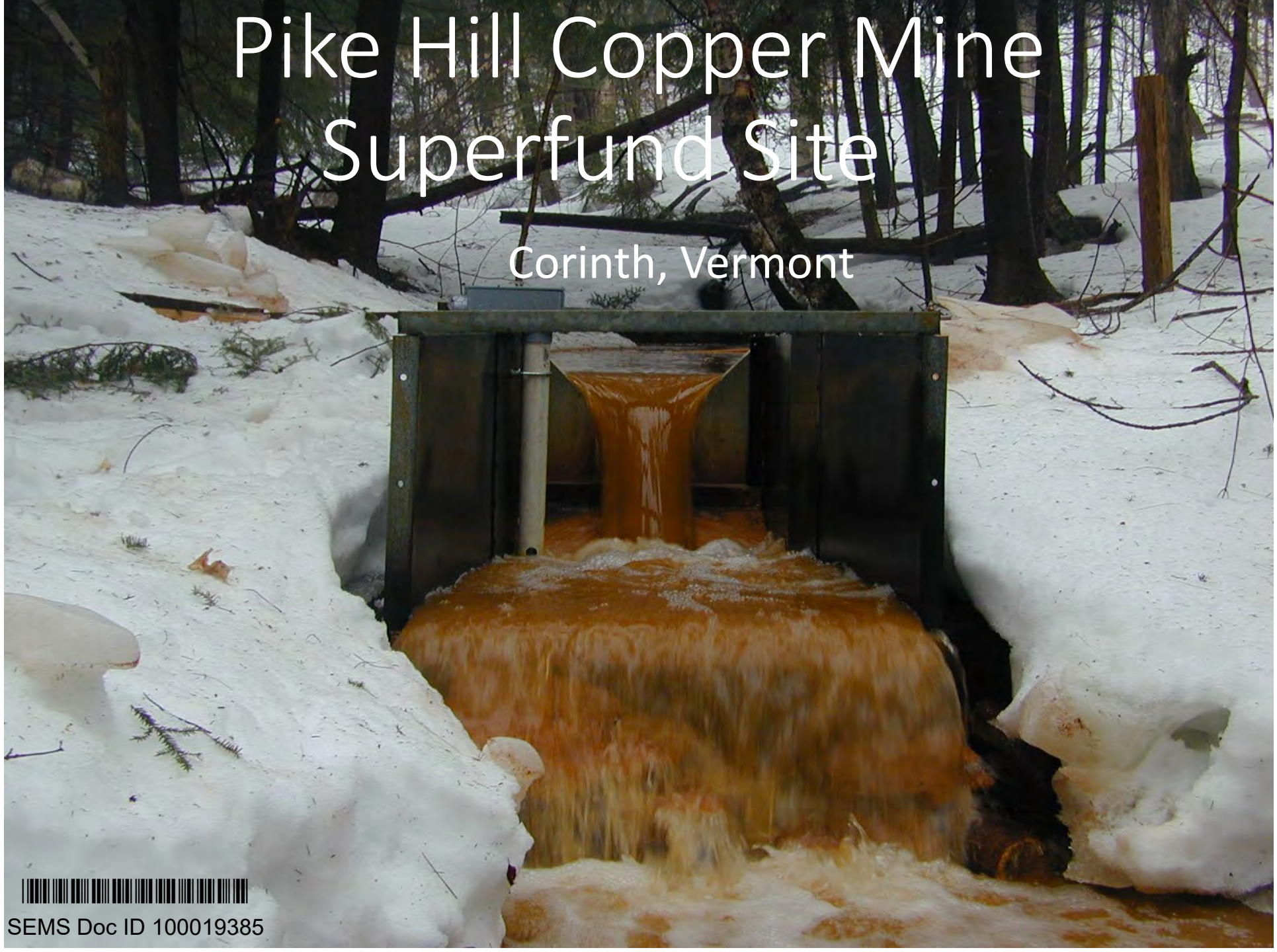
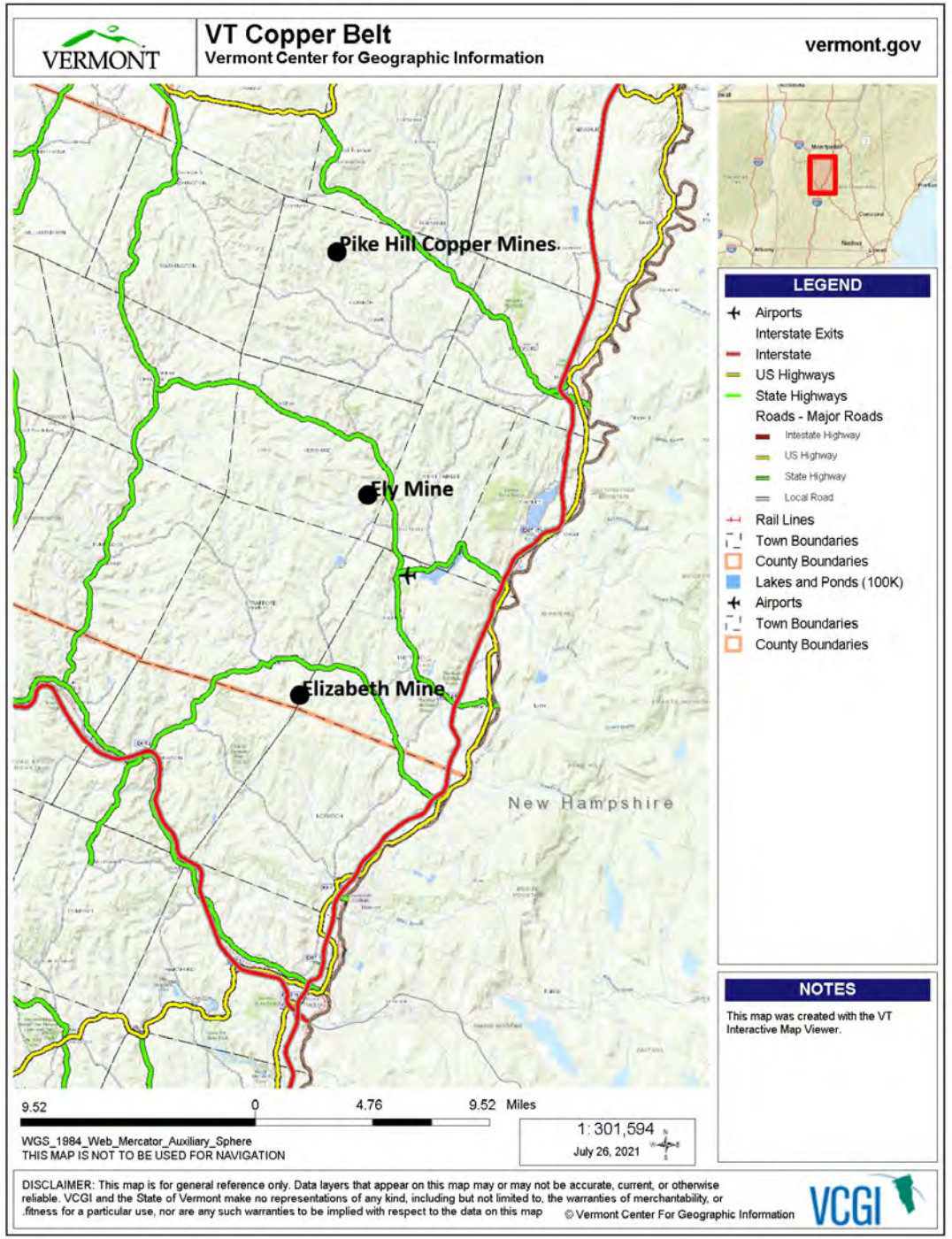
Pike Hill Copper Mine Superfund Site

Corinth, Vermont



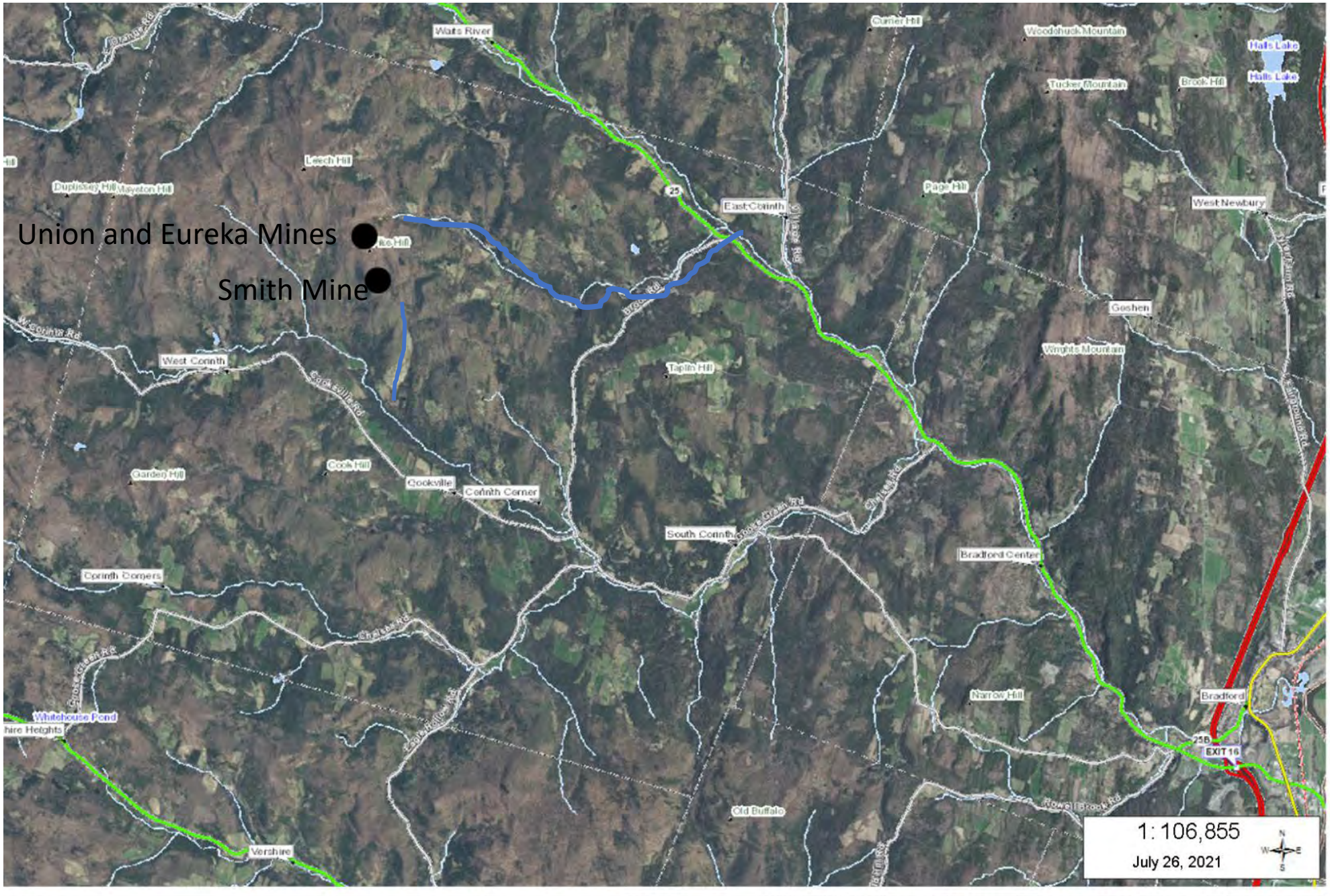
Pike Hill Copper Mine

- The Pike Hill Copper Mine Superfund Site (Site) is located in the Town of Corinth, Orange County, Vermont.
- The Site includes three separate mines: Union, Eureka, and Smith mines.
- The Site was placed on the NPL in 2004.
- The Site is considered eligible for the National Register of Historic Places triggering the requirements of the National Historic Preservation Act.
- The Site hosts the largest known concentration of state-threatened eastern small-footed bats in Vermont and is historic habitat for the federally threatened Northern Long-Eared Bat.



Pike Hill Mine Superfund Site Operational History

- One of three major copper mining sites that operated in the 20-mile-long Orange County, VT, “Copper Belt” during the nineteenth and twentieth centuries along with Elizabeth Mine and Ely Copper Mine.
- Active mining during intermittent periods from 1846 – 1919.
- Ore shipped to Ely Mine smelter from 1878 – 1882 and to Elizabeth Mine flotation mill in late 1940’s and early 1950’s.
- 4,300 tons of copper production.
- 6% of Vermont total copper production.
- Former owner/operators are the same as Elizabeth Mine and Ely Copper Mine and no longer exist.



3.37 0 1.69 3.37 Miles

WGS_1984_Web_Mercator_Auxiliary_Sphere

DISCLAIMER: This map is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. VCGI and the State of Vermont make no representations of any kind, including but not

LEGEND

- Airports
- Roads - Major Roads
  - Intestate Highway
  - US Highway
  - State Highway
  - Local Road
- Rail Lines
- Town Boundaries
- County Boundaries

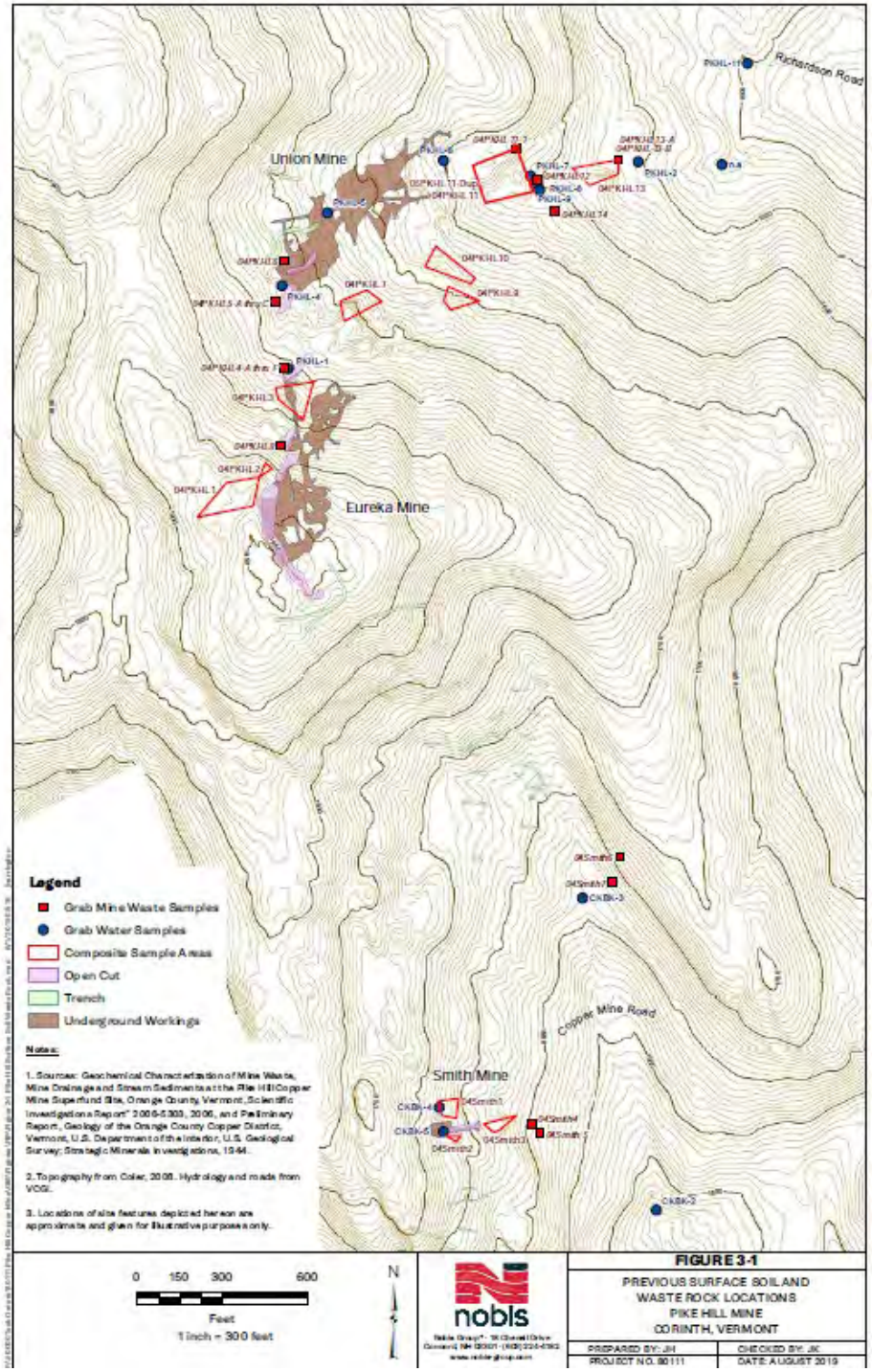
VCGI

NOTES

This map was created with the VT Interactive Map Viewer.

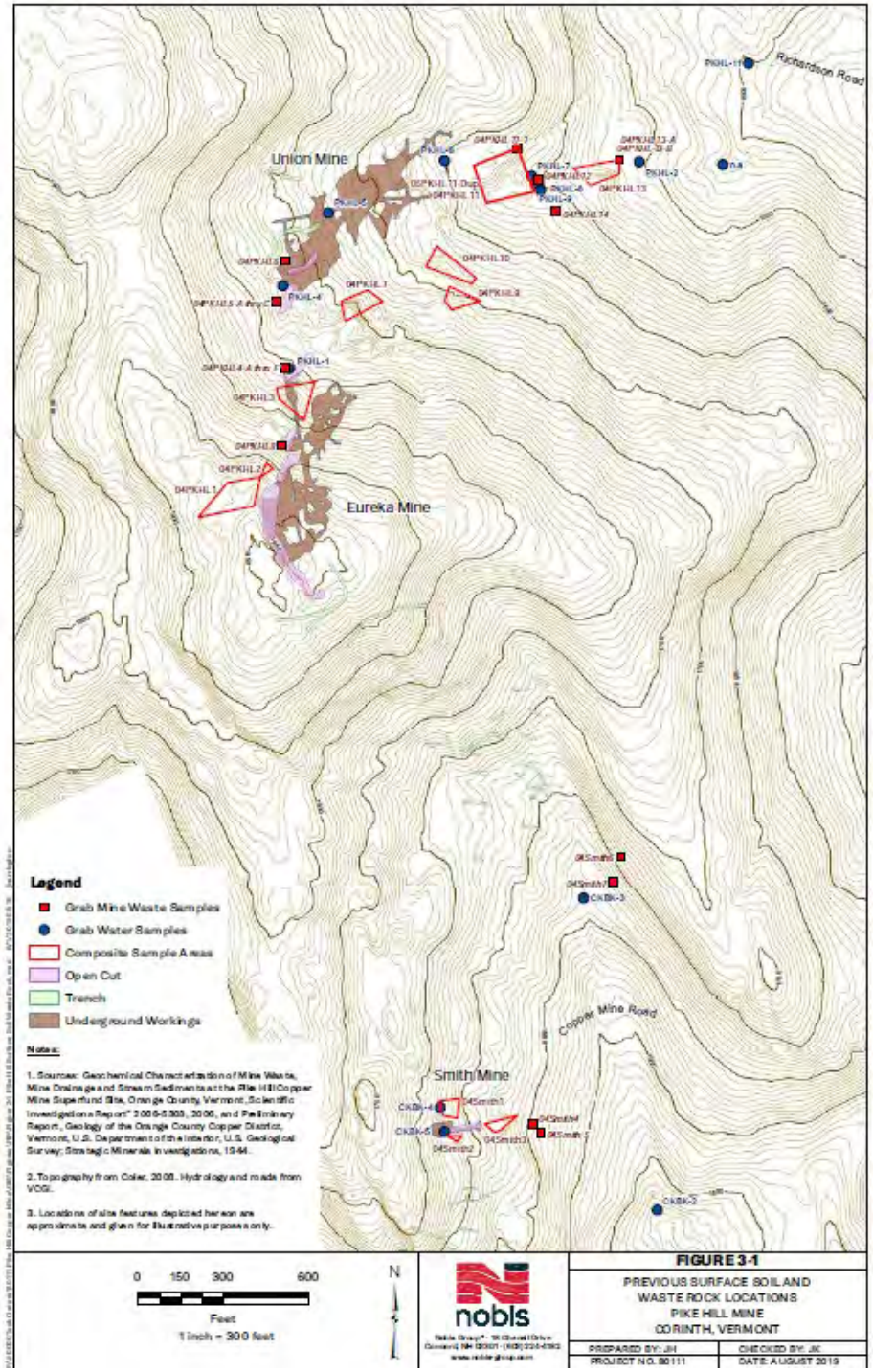
Pike Hill Copper Mine

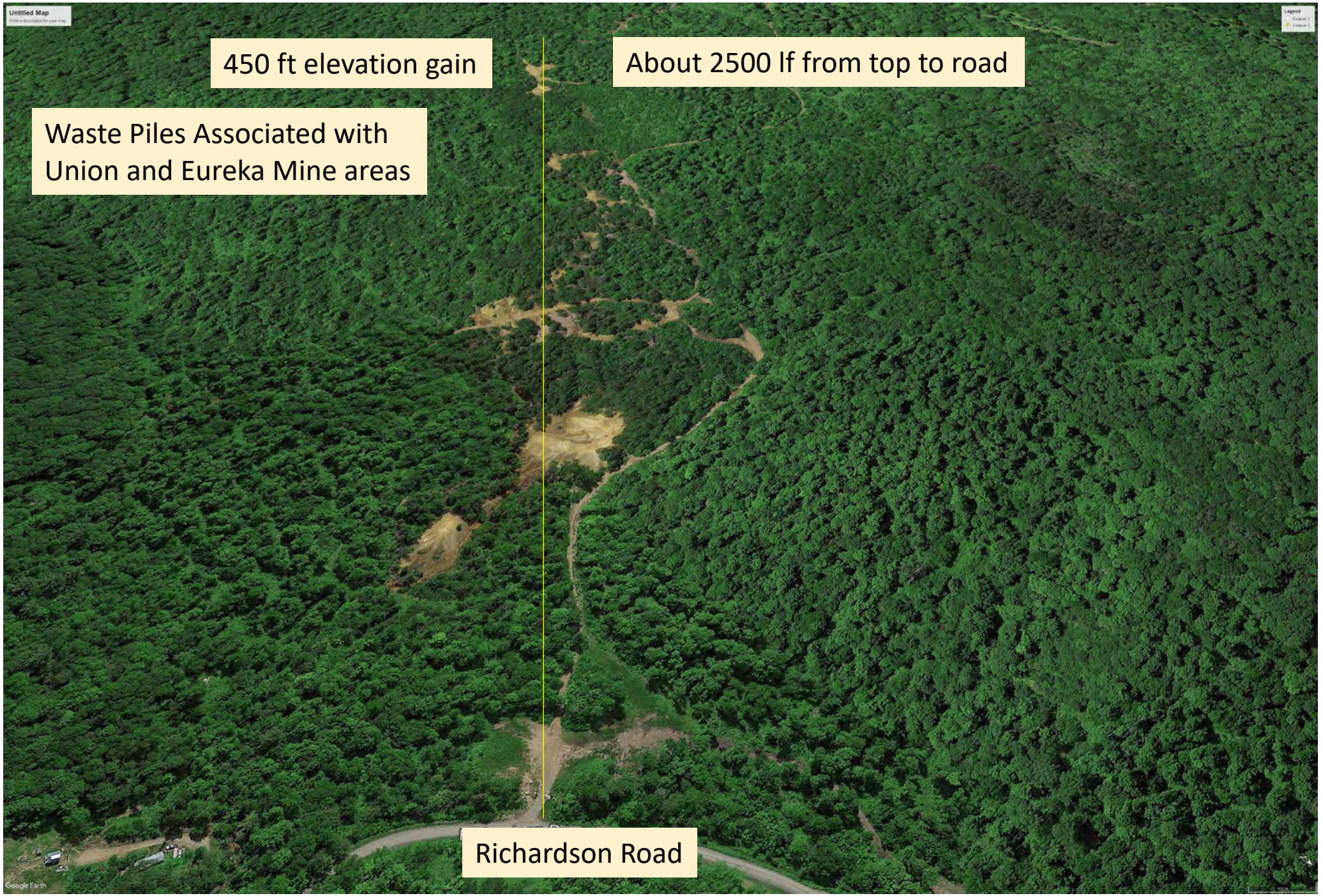
- The NPL listing describes the size of the Site as 216 acres. The exact dimensions to be determined during the RI/FS.
- The Eureka and Union mines are generally considered to be a single-impacted landscape within the Pike Hill Brook watershed containing a barren area of waste rock, tailings piles, open mine cuts, trenches, and mine shafts and adits (some collapsed).
- The Eureka and Union mines are part of one 183-acre property owned by a forest conservation company.
- The Smith Mine is about 0.5 miles south of the other mines. It consists of three small mine waste piles and a collapsed adit and shaft that lie within the Cookville Brook watershed.
- The Smith Mine is part of a separate 100-acre parcel owned by a family.

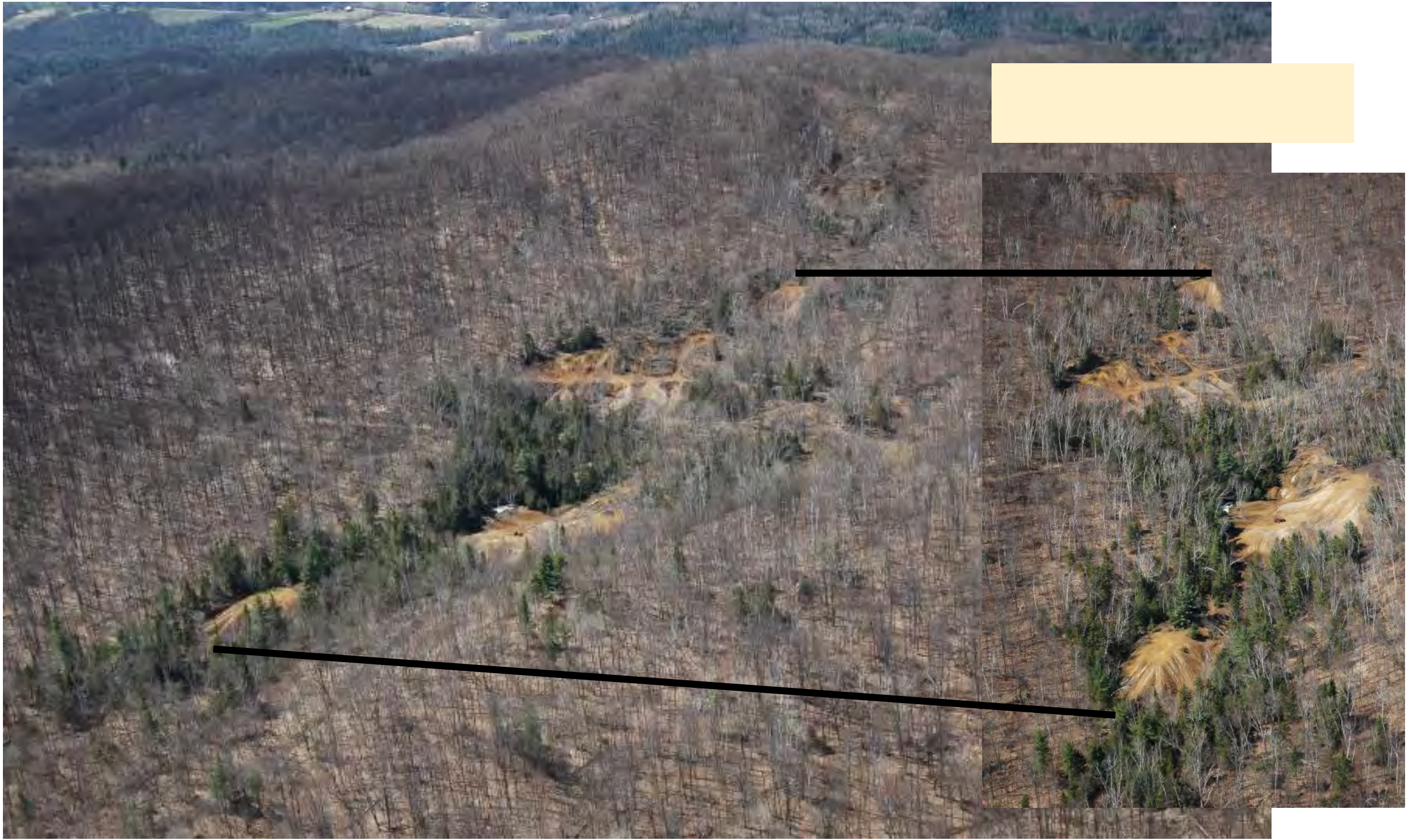


Pike Hill Copper Mine

- The Eureka and Union mines waste areas extend over about 20- 30 acres.
- The Smith Mine waste areas extend over about 3 acres.
- Estimates for the waste rock volume for the entire Site range from 20,000 cubic yards to 50,000 cubic yards of waste rock and tailings piles.
- Based on USGS studies, the ore deposit at the Pike Hill Copper Mine is very similar to the deposit at the Elizabeth Mine and Ely Mine with respect to minerology and physical characteristics.




450 ft elevation gain
About 2500 lf from top to road
Waste Piles Associated with
Union and Eureka Mine areas
Richardson Road




Legend
Feature 1
Feature 2
Google Earth


Union Mine Waste Pile

Union Mine Waste Pile

Union Mine Waste Pile

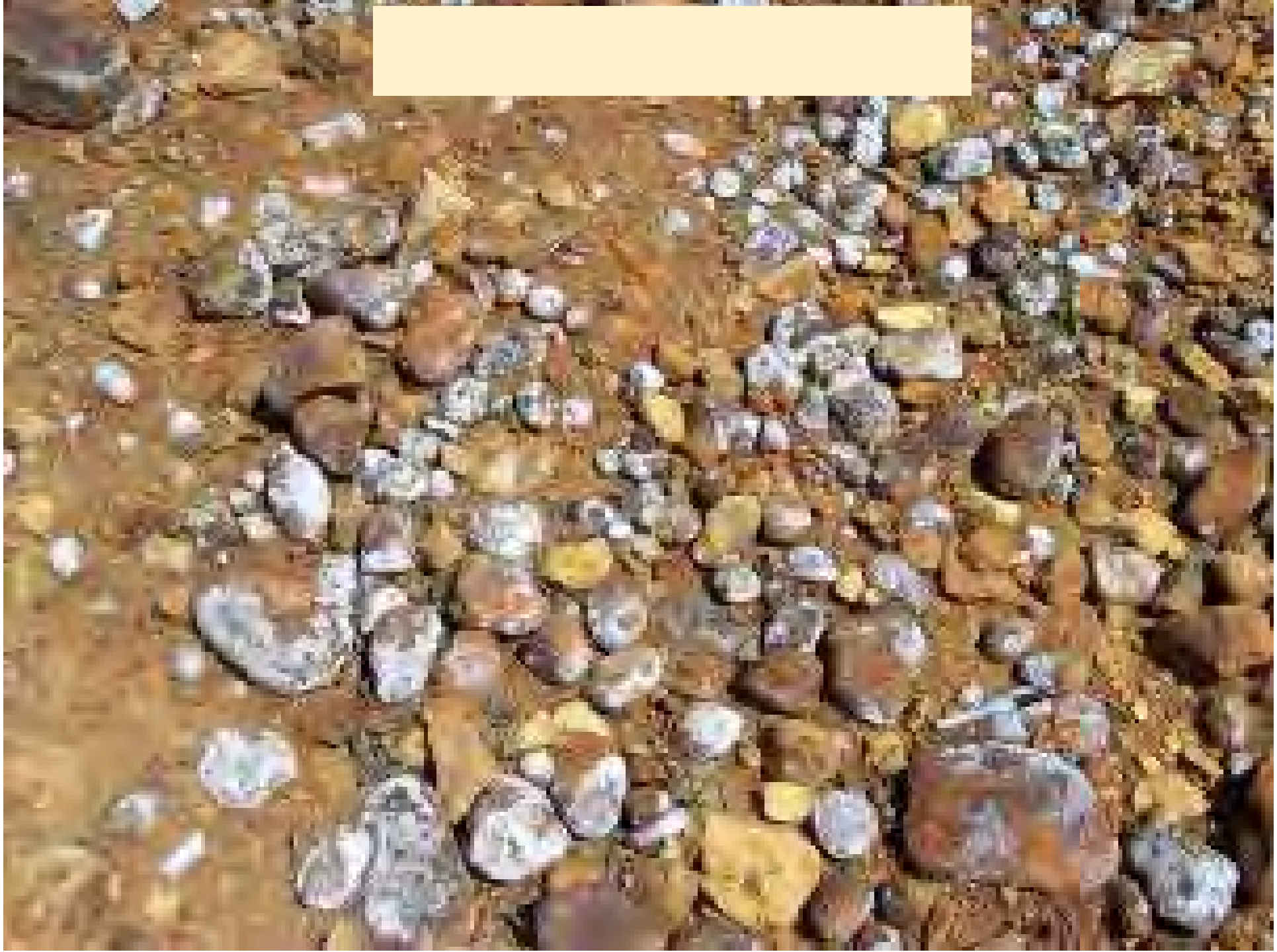

Flotation Mill Tailings Area


Flotation Mill Tailings Area


20 1997


10 15 2004


10. 19. 2004



Aluminum precipitate forms in groundwater seep near Smith mine

Characteristics of Mine Pike Hill Mine Waste

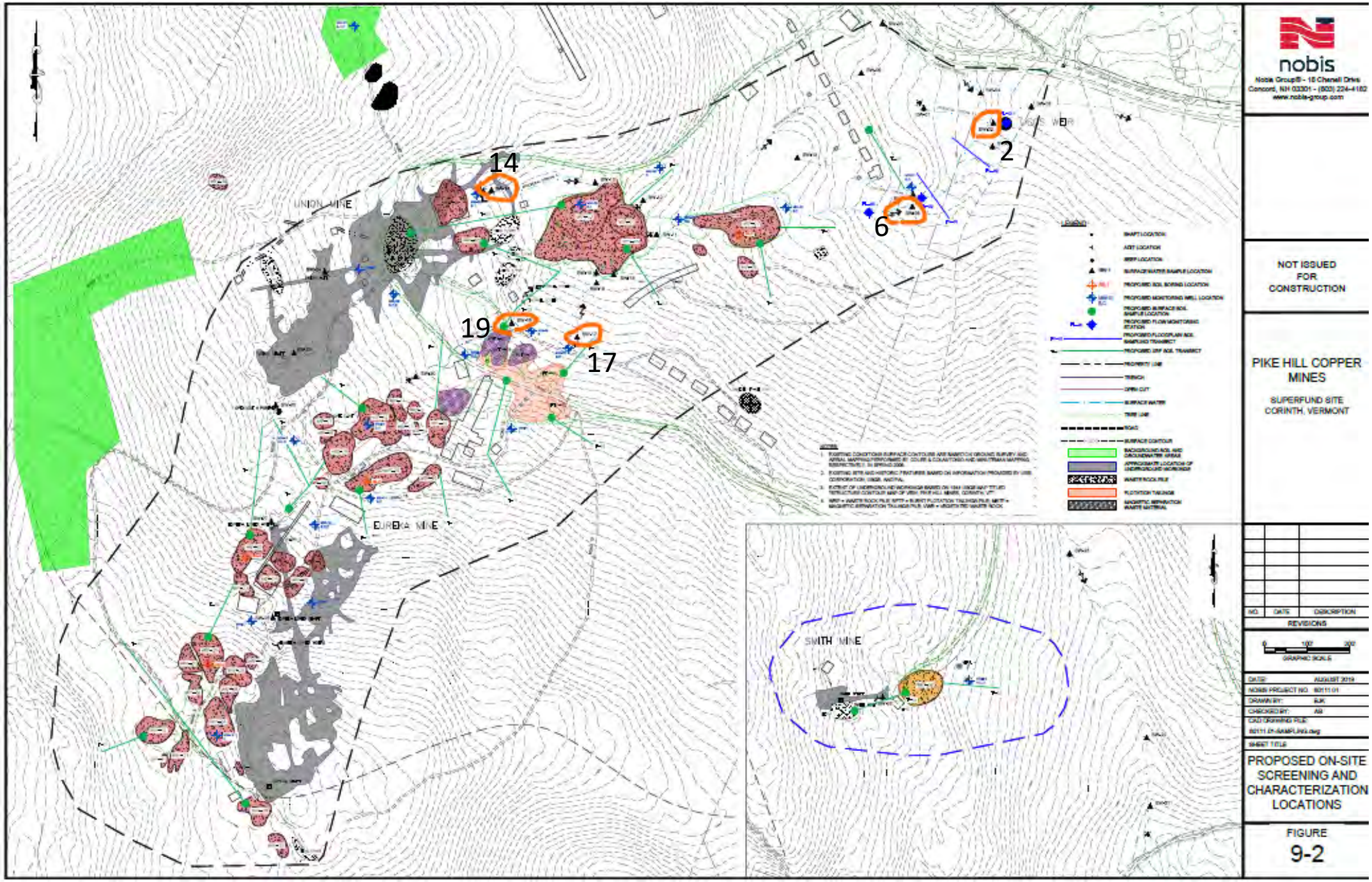
- The contaminant sources at the Pike Hill Copper Mine include:
  - Mine-waste including oxidized and unoxidized sulfidic ore and waste rock, and flotation-mill tailings.
    - Samples contain up to 16 wt. % sulfides that include chalcopyrite, pyrite, pyrrhotite, and sphalerite. The major non-sulfur constituents of significance are cadmium, cobalt, copper, iron, and zinc.
    - During oxidation, sulfides weather and may release potentially toxic trace elements and may produce acid. The past pH of many of the samples was between 2 SU and 4 SU.
    - Soluble efflorescent sulfate salts were identified in the waste piles. The dissolution of these salts during rain and snow melt contributes acid and metals to receiving waters.
    - The leachate from the waste piles and tailings is the major source of metals in Pike Hill Brook and the tributary to Cookville Brook.
  - Discharge from the Underground Workings through seeps and Adit discharge.
  - Downstream sediments are being contaminated through physical transport of mine waste and precipitation of dissolved metals.
  - Downstream wetlands are a sink for the dissolved metal contaminants in surface water and the eroded sediments.

Pike Hill Copper Mine

- Current Site Status:
- Completed work:
  - Waste characterization to confirm waste material is similar to waste at Elizabeth Mine and Ely Copper Mine
  - Aquatic ecological assessment that evaluated:
    - Surface water and sediment toxicity testing
    - Benthic and fish community richness and abundance surveys
    - Surface water and sediment data used to develop hazard quotients
    - Fish tissue sampling
  - Site topographical surveys have been completed
  - RI Work Plan to address remaining data gaps has been developed
  - Conceptual Site Model Report completed
  - Initial Failure Modes and Effects Analysis (FMEA) for Underground Workings completed
  - Several USGS reports documenting surface water flow, chemistry, geochemistry of waste, and summarizing ecological investigations.
  - RI/FS suspended in 2007 due to funding.
  - Surface water and soil samples collected in 2021 to document that site conditions have not changed substantially since initial characterization.
- Remaining work:
  - Groundwater characterization
  - Terrestrial eco characterization
  - Wetland characterization
  - Preparation of major reports (RI, HHRA, BERA, FS)
  - Operable Units are likely to address Underground Workings; Groundwater, and downstream sediments and wetlands

Pike Hill Mine Superfund Site
Surface Water Data

dissolved data collected by EPA May 2021	units	reference standard for toxicity	SW17 Waste Pile leachate	SW19 Waste Pile Leachate	SW2 weir at discharge from Site	Pike 3 0.7 miles downstream of Site	Pike 4 1 mile downstream of Site	Pike 5 Below wetland	Pike 10 Cookville Brook Tributary 10B - Smith Mine	Pike 10A Upstream of Smith Mine
Aluminum	ug/L	87	24,000	23,000	6,100	140	ND	ND	ND	ND
Cadmium	ug/L	0.24	52	40	12	ND	ND	ND	ND	ND
Copper	ug/L	9	22,000	18,000	4,000	170	63	ND	110	ND
Zinc	ug/L	120	5,700	5,800	1,900	400	200	ND	140	ND



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PIKE HILL COPPER MINES

SUPERFUND SITE
CORINTH, VERMONT

NO.	DATE	DESCRIPTION

REVISIONS

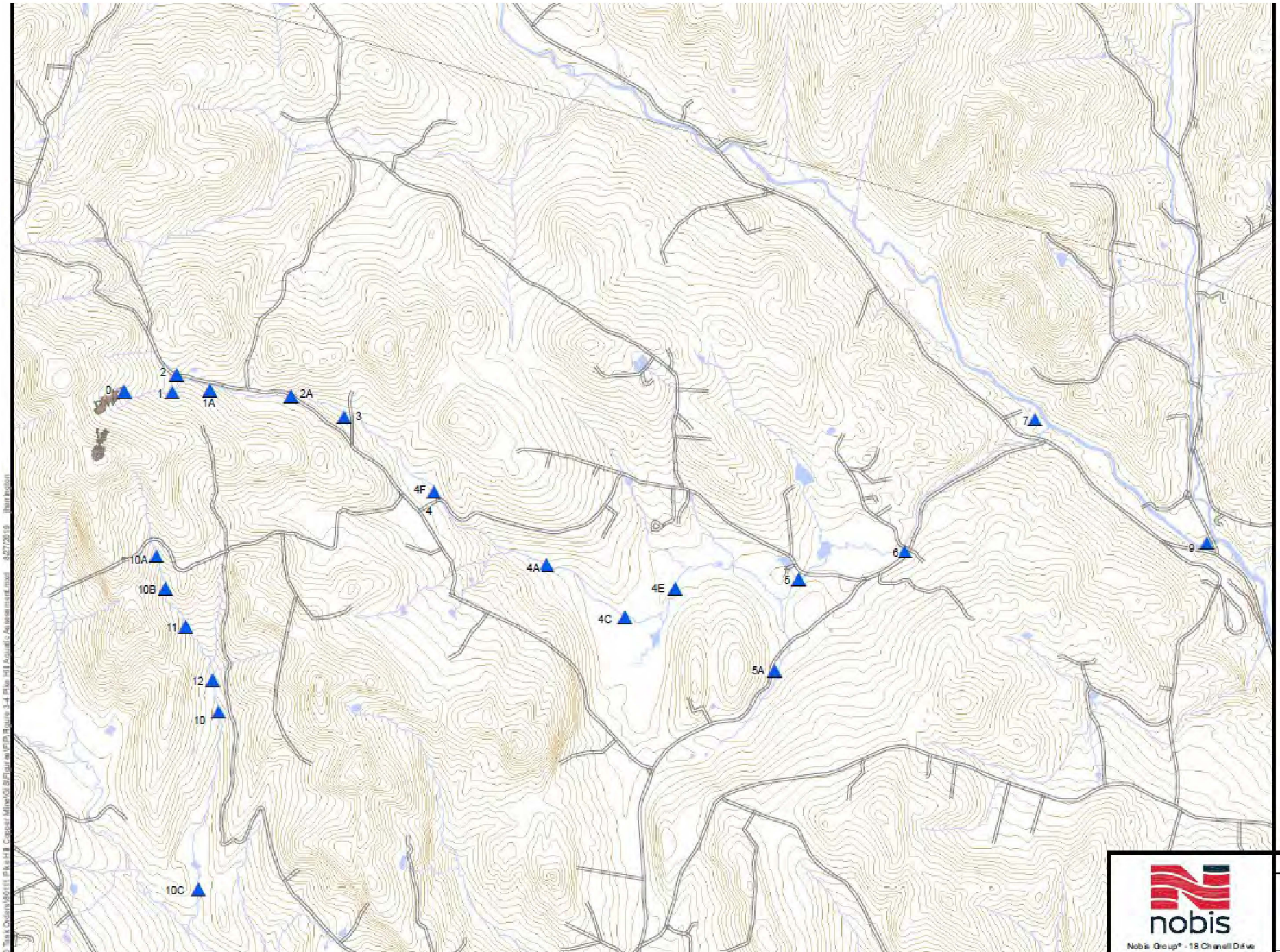
GRAPHIC SCALE

DATE: AUGUST 2019
NOBIS PROJECT NO. 92111.01
DRAWN BY: BJK
CHECKED BY: AM
CAD DRAWING FILE: 92111.01-SAMPLING.dwg

SHEET TITLE

PROPOSED ON-SITE SCREENING AND CHARACTERIZATION LOCATIONS

FIGURE
9-2



Notes:

1. Source: Aquatic Assessment of the Pike Hill Copper Mine Superfund Site, Corinth, Vermont; USGS Scientific Investigations Report 2012-5288. 2012.

2. Topography from Coler, 2008. Hydrology and roads from VCGI.

3. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

Surface Water Samples

- Surface Water Samples
- Underground Workings

0 1,000 2,000 4,000

Feet

N

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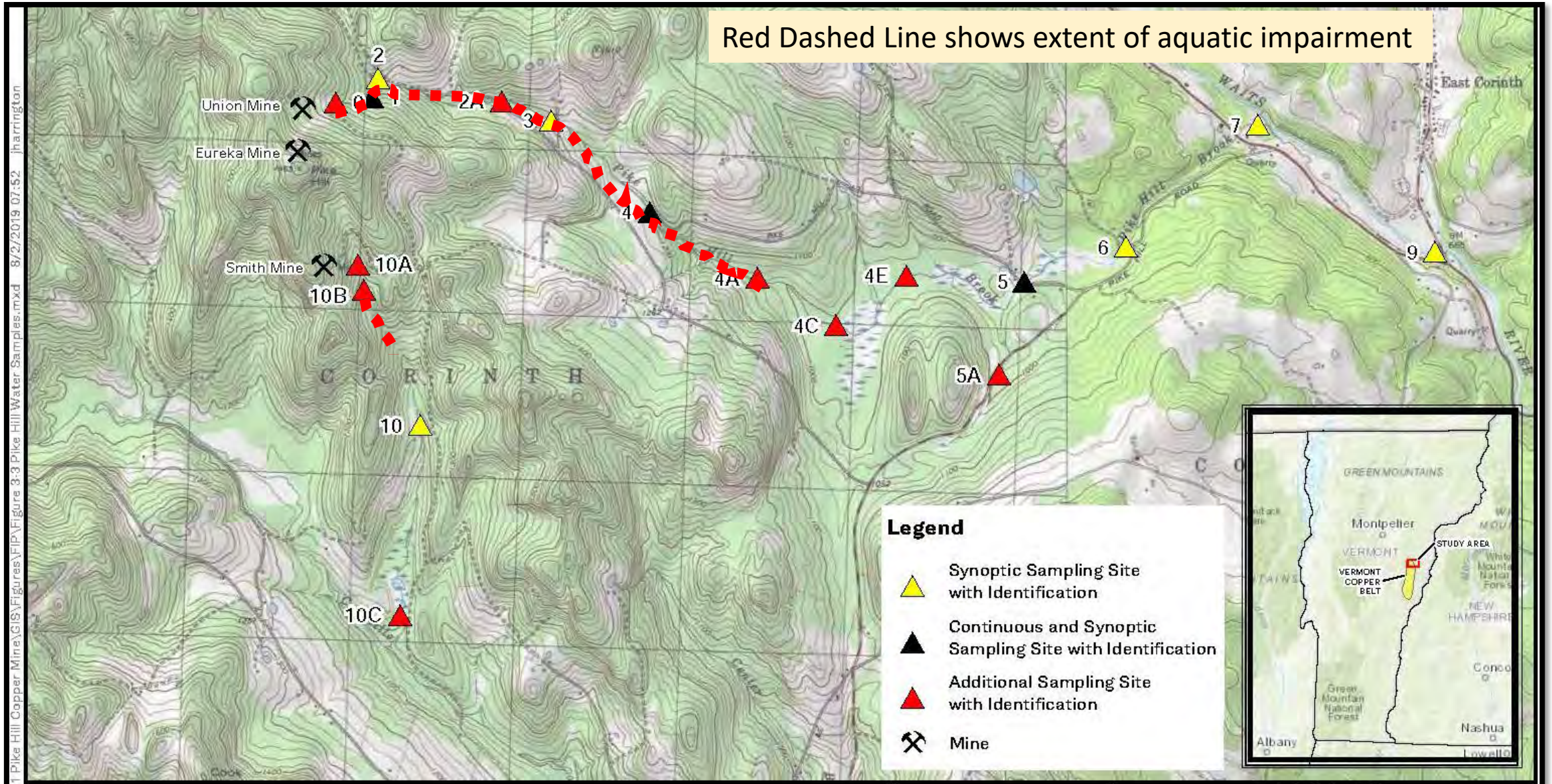
FIGURE 3-4....

USGS AQUATIC ASSESSMENT

(

PIKE HILL MINE

CORINTH, VERMONT



Notes:

1. This figure was developed from information found within the "USGS Surface-Water Hydrology and Quality at the Pike Hill Superfund Site, Corinth, Vermont, October 2004 to December 2005 Scientific Investigations Report 2007-5003."

2. Base from US Geological Survey, West Topsham, 1981 and East Corinth, 1973.

0 0.25 0.5 1
Miles

N

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FIGURE 3-3

WATER SAMPLING SITE LOCATIONS
PIKE HILL COPPER MINE
SUPERFUND SITE
CORINTH, VERMONT

PREPARED BY: JH	CHECKED BY: JK
PROJECT NO. 80111	DATE: AUGUST 2019

F:\80000 Task Orders\80111 Pike Hill Copper Mine\GIS\Figures\FIP\Figure 3-3 Pike Hill Water Samples.mxd 8/2/2019 07:52 jharrington

Pike Hill Copper Mine

Table 2. Summary statistics of physical parameters from the three continuously monitored sites in the Pike Hill, VT, study area.

[ft³/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; min, minimum; max, maximum. Refer to figure 1 and table 1 for site names, station numbers, and locations]

Site number (table 1; fig. 1)	Streamflow (ft³/s)				Specific conductance (µS/cm)				pH (standard units)				Water temperature (°C)			
	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
[1]1	0.01	0.26	0.17	2.5	134	705	628	2,210	2.7	3.6	3.6	4.4	0.0	7.2	5.4	22.7
[2]4	.06	1.75	.89	16.0	130	240	253	327	6.1	7.2	7.6	7.8	.0	10.6	13.2	20.6
[1]5	.21	6.20	4.32	108	100	204	194	364	7.1	7.5	7.6	7.9	.0	7.8	4.7	26.9

[1] Statistics based on data collected from November 2004 to December 2005.

[2] Statistics based on data collected from June 2005 to December 2005.

Pike Hill Copper Mine

Pollutants	Acute standard (µg/L)	Percentage of samples exceeding acute toxicity standards								
		Site 1	Site 3	Site 4	Site 5	Site 6	Site 7	Site 9	Site 10	Back-ground[1]
Priority pollutant										
Cadmium[2]	2.0	100	50	44	0	0	0	0	0	0
Copper[2]	13	100	100	78	32	25	25	0	0	0
Zinc[2]	120	100	100	56	0	0	0	0	0	0
Non-priority pollutant										
Aluminum[3]	750	100	0	0	0	0	0	0	0	0

Pollutants	Chronic standard (µg/L)	Percentage of samples exceeding chronic toxicity standards								
		Site 1	Site 3	Site 4	Site 5	Site 6	Site 7	Site 9	Site 10	Back-ground[1]
Priority pollutant										
Cadmium[2]	0.24	100	100	100	26	25	25	0	0	0
Copper[2]	8.8	100	100	89	58	50	50	0	33	0
Zinc[2]	120	100	100	56	0	0	0	0	0	0
Non-priority pollutant										
Aluminum[3]	87	100	0	0	0	0	0	0	0	0
Iron	1,000	100	25	11	0	0	0	0	0	0

[1] Sites 2 and 8 (refer to table 1).

[2] Acute and chronic toxicity standards adjusted for hardness of 98 milligrams per liter (mg/L).

[3] Acute and chronic toxicity standards for waters with pH 6.5–9.0 and for total recoverable concentrations.

Pike Hill Copper Mine

Table 5. Summary statistics for concentrations of sulfate, calcium, aluminum, iron, cadmium, copper, and zinc in water samples and a stream-sediment sample collected at sites in the Pike Hill, VT, study area.

[QW, water quality; mg/L, milligrams per liter; µg/L, micrograms per liter; min, minimum; max, maximum; <, less than; --, not calculated; %, percent; mg/kg, milligrams per kilogram. Refer to figure 1 and table 1 for site name, station number, and location]

Site number (table 1; figure 1)	Number of QW samples	Dissolved concentration															
		Sulfate (mg/L)				Calcium (mg/L)				Aluminum (Al) (µg/L)				Iron (Fe) (µg/L)			
		Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
1	24	242	373	324	691	54.1	64.7	62.2	96.8	5,680	8,630	7,860	15,200	8,440	37,500	25,000	150,000
2	4	7.6	8.1	8.0	8.9	21.9	32.8	34.3	40.9	2	3	2	4	<50	--	<50	<50
3	4	95.0	118	106	162	36.7	44.8	45.0	52.6	10	14	14	20	<50	--	<50	18,700
4	9	31.7	56.8	51.0	97.0	26.1	36.8	37.4	45.1	<2	--	8	22	<50	--	--	2,680
5	19	7.1	16.2	14.1	32.2	14.7	27.8	29.5	39.8	2	9	8	18	<50	--	--	230
6	4	5.7	12.6	14.3	16.3	20.3	31.0	32.3	39.0	4	7	6	12	70	120	120	160
7	4	6.7	12.5	13.6	16.1	19.1	30.5	31.8	39.4	3	7	7	13	<50	--	--	110
8	4	6.0	6.8	6.5	8.0	21.9	31.5	32.3	39.5	5	11	12	16	<50	--	<50	<50
9	4	6.9	10.4	8.2	18.1	22.3	32.0	33.8	37.9	6	11	11	17	<50	--	<50	240
10	3	11.6	14.2	15.0	16.0	41.6	46.8	45.1	53.8	15	36	30	64	<50	--	<50	<50

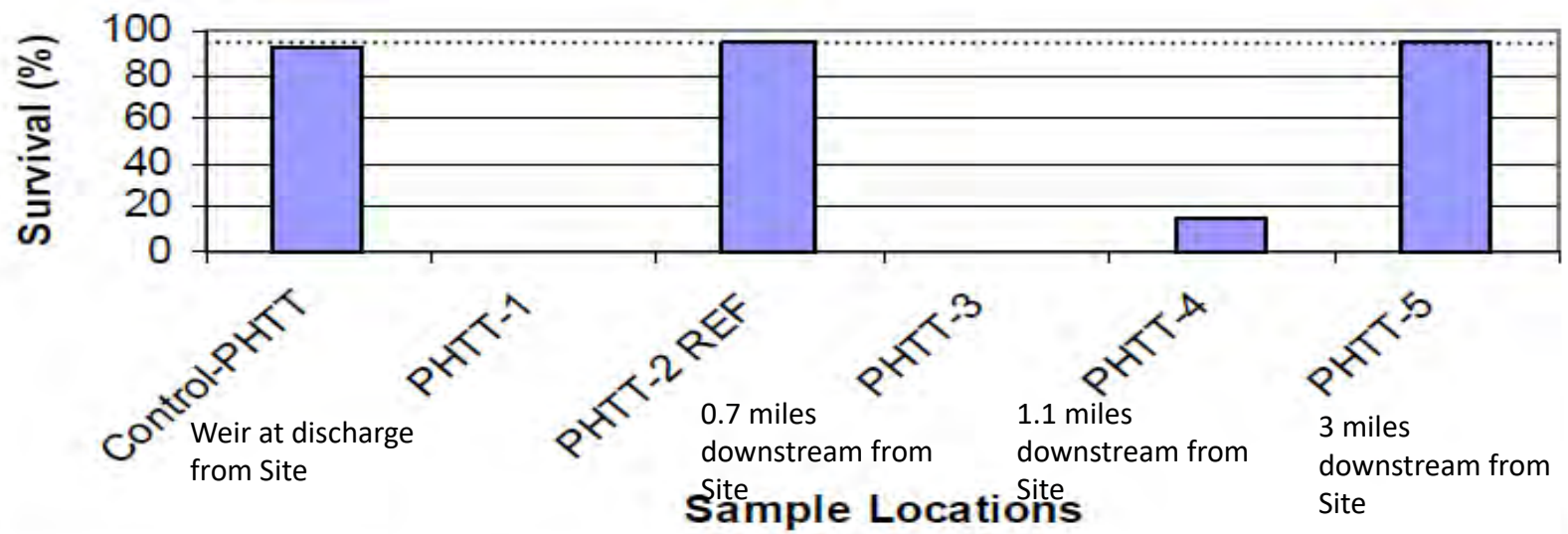
Site number	Number of QW samples	Dissolved concentration												Stream sediment concentration[1]				
		Cadmium (Cd) (µg/L)				Copper (Cu) (µg/L)				Zinc (Zn) (µg/L)				Al	Fe	Cd	Cu	Zn
		Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	(%)	(%)	(mg/kg)	(mg/kg)	(mg/kg)
1	24	8.11	25.6	18.8	92.8	1,940	6,900	3,720	30,800	1,870	3,230	2,670	7,340	3.03	21.5	5.8	8,070	1,070
2	4	<0.02	--	<0.02	<0.02	0.5	0.8	0.7	1.5	<0.5	--	1	2	5.76	3.36	0.5	262	134
3	4	1.61	6.40	2.54	18.9	24.0	848	38.0	3,290	247	674	380	1,690	5.08	7.64	3.2	3,530	675
4	9	.45	2.29	1.05	5.84	7.9	85.5	25.5	299	42	295	124	631	4.96	6.67	4.8	3,540	834
5	19	.08	.19	.16	.49	3.9	12.2	9.6	37.1	9	27	22	65	5.36	2.72	1.6	298	283
6	4	.09	.18	.15	.32	4.9	14.0	9.6	33.0	10	21	14	46	4.62	1.84	.9	119	191
7	4	.04	.12	.07	.28	4.3	13.0	8.0	30.0	5	16	9	40	4.29	1.4	1.4	98.1	224
8	4	<.02	--	<.02	<.02	<.5	--	<.5	0.5	<.5	--	--	3	3.8	2.04	.1	7.7	44
9	4	<.02	--	<.02	.02	.6	1.1	1.1	1.7	1	2	2	4	4.06	1.35	.1	8.0	43
10	3	.10	.13	.11	.18	3.6	6.3	4.0	11.0	13	18	15	25	4.74	2.43	1.5	539	685

[1] From Piatak and others, 2006b.

Table 6: Percent Survival for the *P. promelas* 7-day Pike Hill Mine Surface Water Toxicity Test					
Lab Control	**PHTT-1**	**PHTT-2 REF**	**PHTT-3**	**PHTT-4**	**PHTT-5**
92.5%	0%	95%	0%	15%	95%

The test met the TAC for survival (80%), with 92.5% survival in the laboratory control. In addition, the survival in the reference sample (PHTT-2 REF) and in PHTT-5 was 95%. The 7-day survival data were evaluated using Steel's Many-One Rank Test to determine if there was a significant ($p \leq 0.05$) difference in survival between the mine samples and the reference sample. Significant differences were found between the reference sample (PHTT-2 REF) and PHTT-1, PHTT-3, and PHTT-4. The results of the comparisons are summarized in **Figure 3** below.

Figure 3. Summary of Pike Hill Mine *P. promelas* Survival Results



..... Background sample reference line (PHTT-2 REF)
The TAC require control survival of at least 80%

Pike Hill Copper Mine Aquatic Assessment Summary

Summary of geochemical and biological indicators of stream health in the Pike Hill Copper Mine study area, Corinth, VT.

[Pink cells indicate impaired, green cells indicate unimpaired, yellow cells indicate uncertain level of impairment, and white cells indicate no criteria were available for comparison]

	Pike Hill Brook watershed														
	Reference		Reference	Upper		Lower									
	2	5A	10D	1	4	4A	5	6	10A	10B	11	12	10	10C
Surface-water quality indicators	Upstream Pike Hill Brook	reference stream	reference stream	on-site weir	1 miles downstream	1.6 miles downstream	3 miles downstream	3.8 miles downstream	tributary upstream of Smith Mine	tributary where drainage from Smith Mine enters stream	downstream of 10B	downstream of 10B	downstream of 11 and 12	downstream of 10
Surface water hardness-based hazard quotient[a] for Cu	**0.1**	**0.0**	**0.4**	**101**	**1.4**	**1.1**	**1.0**	**0.8**	**0.1**	**11**	**1.3**	**1.0**	**0.3**	**0.2**
Surface water hardness-based hazard index[b]	**0.1**	**0.1**	**0.6**	**137**	**4.5**	**5.9**	**1.6**	**1.3**	**0.1**	**16**	**2.7**	**1.8**	**0.6**	**0.2**
Surface water toxicity test fathead minnow survival % (2006)	**95.0**	-	-	**0**	**15.0**	-	**95.0**	-	-	-	-	-	-	-
Benthic RTH abundance (collected in 2007)	-	-	**839**	**30**	**152**	**261**	**1736**	**805**	**827**	**32**	-	-	**289**	**1416**
Bethic RTH richness (collected in 2007)	-	-	**55**	**6**	**31**	**28**	**54**	**36**	**48**	**17**	-	-	**47**	**41**
Benthic RTH assessment (based on 2005 and 2007 samples)	-	-	**excellent-very good**	**not assessed**	**poor**	**poor**	**fair & good**	**good-fair & fair**	**good**	**poor**	-	-	**good-fair**	**excellent-very good**
Blacknose dace CBR[c]-based hazard quotient for Cu (µg/g, wet wt.)	-	-	**0.3**	-	-	**1.8**	**1.6**	**1.1**	-	-	-	-	-	**0.3**
Summary assessment based on surface-water quality indicators	**good**	**good**	**good**	**impacted**	**impacted**	**impacted**	**uncertain**	**uncertain**	**good**	**impacted**	**uncertain**	**uncertain**	**uncertain**	**good**

[a] Hazard quotients > 1 indicate concentration above environmental criteria.

[b] Sum of the hazard quotients for Cu, Cd, Ni, Pb, and Zn.

[c] Critical Body Residue value for salmonids for Cu is 2.4 µg/g wet weight.

Pike Hill Copper Mine

Risk Evaluation Summary

- The discharge from the Pike Hill Mine Superfund Site is causing acute toxicity (100% mortality) in surface water toxicity tests performed in surface water in the tributary from the Pike Hill Mine Superfund Site that drains into Pike Hill Brook and in Pike Hill Brook after the confluence with the discharge from the Pike Hill Mine Superfund Site.
- Copper concentrations in the water of the tributary to Pike Hill Brook and in Pike Hill Brook after the confluence with the discharge from the Pike Hill Mine Superfund Site exceed Vermont Water Quality numerical standards and federal Clean Water Act National Recommended Water Quality Criteria.
- The benthic community and fish community of Pike Hill Brook are severely impaired by the release from the Pike Hill Superfund Site for several miles below the confluence of the water from the Pike Hill Mine Superfund Site with Pike Hill Brook.

Pike Hill Copper Mine

- Why a Non-Time Critical Removal Action (NTCRA):
  - Site represents a severe ongoing ecological threat as documented by multiple lines of evidence.
  - Targeted source control action would greatly reduce acute impacts and reduce loading to downstream wetland area while RI/FS is being completed.
  - Consistent with early cleanup construct for Superfund.
  - Source control action is consistent with long-term cleanup approach to allow for exemption from $2 million limit.
  - Several more years to complete RI/FS and sign a ROD.

Pike Hill Copper Mine

- Removal Action Objectives
  - Isolate mine waste from water and oxygen to minimize the migration of contamination into Pike Hill Brook and a tributary of Cookville Brook.
  - Limit tree clearing and other disturbance to minimize impact on the habitat, including the hibernacula, for federal and state threatened and endangered bats.
- Cleanup levels would be VT Water Quality Standards and federal National Recommended Water Quality Criteria, as measures in stream downgradient of Waste Management Area.
- No soil cleanup levels, the material of concern would be based on minerology (sulfide minerals and ore) and location.
- ARAR analysis would be identical to those at Elizabeth Mine and Ely Mine.

Pike Hill Copper Mine

Based on experience from Elizabeth Mine and Ely Copper Mine, the most likely alternatives to be developed in the EE/CA include:

1. On site consolidation and capping of mine waste material, including Smith Mine piles.
2. Partial on-site consolidation and capping of mine waste material, including Smith Mine piles with in-situ covering of waste in proximity to the Bat Hibernacula that cannot be removed with disturbing the tree cover or other critical criteria.
3. Off-site disposal of mine waste material.
4. Passive treatment of Adit seeps and other seeps.

Pike Hill Copper Mine

Available documents for Admin Record:

- Nobis, 2019. Draft Remedial Investigation Field Investigation Plan, Pike Hill Copper Mine Superfund Site Operable Unit 01, Corinth, Vermont. July.
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Pike Hill Copper Mine

Conceptual Model of Contamination:

- The major issue at the Site is Acid Rock Drainage, which occurs when sulfide mineral-bearing rock and ore are exposed to oxidizing conditions through natural weathering processes. ARD occurs in response to the oxidation of waste rock, waste ore, tailings, slag, and roasted ore. The contaminated water that flows from the underground adits and shafts is more commonly referred to as AMD. The geochemical reactions responsible for the oxidation of sulfide minerals, such as pyrrhotite, are driven by the availability of atmospheric oxygen and water. These geochemical reactions produce sulfuric acid, which results in the generation of low-pH (typically less than 4.0 standard units) leachate. At low pH, many of the metals that were bound in the ore and native soil become soluble and dissolve into the leachate. The leachate from the Site often contains elevated levels of aluminum, cadmium, cobalt, copper, iron, manganese, and zinc that are likely from the locally mined ore. Aluminum and manganese are also contributed by the leaching of metals in the native soil. In addition to the oxidation of the sulfide-bearing minerals, the cyclic formation and subsequent dissolution of evaporative metal salts on exposed waste ore and tailings also contributes to ARD at the Site. Metal salts form on the surfaces of the tailings and waste ore piles as metal-containing acidic moisture evaporates. The metals stored in these salts are dissolved and remobilized during subsequent rainfall events. This run-off eventually is conveyed to receiving streams resulting in an increase in the metals concentration and load.

- Metals associated with ARD at the Site have been detected at elevated concentrations in surface water, soil, and sediment. ARD directly affects surface water quality at the Site by lowering the pH and contributing elevated concentrations of metals. This also occurs at the outlet of the adits where impacted mine waters discharge directly to the ground surface as AMD. In addition, the tailings and weathered waste ore have been transported from the original areas of deposition by erosion and re-distributed nearby, causing elevated concentrations of metals in the soil adjacent to the waste areas. Some of these materials have been conveyed by overland flow, resulting in elevated concentrations of metals in sediment and downstream wetland.